

Intracardiac Masses I-Mass Study Single Center Experience Within 12 Years

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Abstract

Objective : The aim of this cross-sectional, retrospective, descriptive study was to review and classify cardiac masses systematically and to determine their frequencies.

Methods : The medical records of 64,862 consecutive patients were investigated within 12 years. Every patient with a cardiac mass imaged by transthoracic echocardiography (TTE) and confirmed with an advanced imaging modality such as transesophageal echocardiography (TEE), computed tomography (CT) and / or cardiac magnetic resonance imaging (CMR) was included. Acute coronary syndromes triggering thrombus formation, vegetations, intracardiac device and catheter related thrombi were excluded.

Results : Data demonstrated 127 (0.195 %) intracardiac masses consisting of 33 (0.050 %) primary benign, 3 (0.004 %) primary malignant, 20 (0.030 %) secondary tumors, 3 (0.004 %) hydatid cysts and 68 (0.104 %) thrombi respectively. The majority of primary cardiac tumors were benign (91.67 %), predominantly myxomas (78.79 %), and the less malignant (8.33 %). Secondary cardiac tumors were common than the primary malignant tumors (20:3), with male dominancy (55 %), lymphoma and lung cancers were the most frequent. Intracardiac thrombi was the majority of the cardiac masses, thrombi accompanying malignancies were in the first range (n=17, 25%), followed by autoimmune diseases (n=13, 19.12 %) and ischemic heart disease with low ejection fraction (n=12, 17.65 %).

Conclusion: This retrospective analysis identified 127 patients with cardiac masses. The majority of benign tumors were myxoma, the most common tumors that metastasized to the heart were lymphoma and lung cancers, and the thrombi associated with malignancies and autoimmune diseases were the most frequent.

Key Points

1. Intracardiac masses are rare entities
2. The majority of primary cardiac tumors are benign, predominantly myxomas
3. Primary malignant cardiac tumors are very rare
4. Secondary cardiac malignant tumors are much more common than the primary malignant tumors with male dominancy
5. The most common tumors that metastasize to the heart are lymphoma and lung cancer
6. Intracardiac thrombi is the majority of cardiac masses, thrombi accompanying malignancies are the most frequent followed by autoimmune diseases predominantly located in the right atrium
7. This descriptive analysis may contribute to appropriate diagnosis of patients with a cardiac mass, which principally rely on correct recognition of the masses made generally based on their localizations and imaging characteristics.

Introduction

Cardiac masses include primary and secondary tumors, cysts, thrombi, and vegetations. The studies published to date include either autopsy data¹, clinical features and treatment options in specific groups of cardiac masses²⁻⁶, imaging modalities^{5,7-9}, or global reviews¹⁰⁻¹⁵ and case reports. The incidence rates of cardiac masses differ between studies and autopsy series. No study addressing cardiac masses of the heart cavity collectively including tumors, cysts and thrombi has yet been reported. The aim of this cross-sectional, retrospective, descriptive study was to determine the frequencies of intracardiac masses consisting of primary and secondary tumors, cysts and thrombi in hospitalized and out-patients referred to the echocardiography laboratory within twelve years.

Methods

To identify patients with cardiac masses, we retrospectively reviewed the medical records of 64,862 patients referred to the echocardiography laboratory between 2006 - 2017. Every patient with a suspected cardiac mass imaged by two and/or three dimensional (2D - 3D) transthoracic echocardiography (TTE) and confirmed with an advanced imaging modality such as transesophageal echocardiography (TEE), computed tomography (CT) and / or cardiac magnetic resonance imaging (CMR) was included. Patients with a history of acute myocardial infarction within six months and left ventricular apical thrombus, left atrial appendage thrombus revealed by TEE before cardioversion for atrial fibrillation, cardiac masses associated with mechanical or bio-prosthetic valves, vegetations of proven infective endocarditis and intracardiac device and / or catheter / lead induced thrombi were excluded, de-novo thrombi were evaluated.

Data collection and evaluation was started at the beginning of 2018, and completed by the end of 2019.

Echocardiographic examinations were performed using Vivid 7 Dimension (GE Vingmed Ultrasound AS, Horten, Norway) and iE33 xMatrix - DS ultrasound imaging system (Philips Ultrasound, Bothell, WA). The first step examination for all patients with a definite mass in the heart, including the aortic and pulmonary roots was 2D and/or 3D TTE and TEE with standard views performed according to the guidelines^{16,17}. The anatomical localization of the mass, mobility, echogenicity, tissue properties, pedicle, if present, relation to adjacent cardiac structures, invasions and extensions, effects on blood flow and valve functions were examined and recorded and the patient was referred to CT and / or CMR before the appropriate treatment decision.

Contrast-enhanced CT was performed with a 4-MDCT scanner (Somatom Sensation 4, Siemens Medical Solutions) and a helical CT scanner (Somatom Plus-S, Siemens Medical Solutions) to investigate the size, location, morphology and tissue characteristics. For right atrial (RA) and right ventricular (RV) masses, intravenous contrast injection was performed to obtain optimal images and low-dose non-contrast and delayed CT imaging was performed in distinguishing intracardiac thrombus from tumor.

CMR was performed with a 1.5T system (Symphony, Siemens Medical Solutions, Erlangen, Germany) with ECG triggering, tissue characterization with T1- and T2-weighted images. Cine images, T1- and T2-weighted turbo spin echo, first-pass perfusion were used in patients referred to CMR with a diagnosis of a cardiac mass and TI scout sequences mainly for the diagnosis of tumors.

The researchers were allowed to obtain data from the general archives of the imaging devices and the electronic archives of the hospital with the authority granted by the institution. Patients and/or public were not involved in the design. The study was approved by Istanbul Faculty of Medicine Ethics Committee (75486), and conforms the principles outlined in the Declaration of Helsinki.

STATISTICS

All statistical tests were performed using SPSS software, version 16. Descriptive statistic was applied in calculation of the frequencies.

Results

Data from 64.862 patients within 12 years demonstrated 127 (0.195 %) intracardiac masses consisting of; 36 primary tumors (0.056 %), 33 (0.050 %) primary benign, 3 (0.004 %) primary malignant; 20 (0.030 %) secondary tumors; 3 (0.004 %) cysts and 68 (0.104 %) thrombi respectively (Table 1).

Primary benign cardiac tumors

Twenty six myxomas were identified (78.79 % of benign tumors; 20.47 % of cardiac masses 0.04 % of the study group), followed by 5 papillary fibroelastomas (15.15 % of benign tumors; 3.94 % of cardiac masses, 0.007 % of the study group), 1fibroma and 1 lipoma (3.03 % of benign tumors, 0.78 % of cardiac masses, 0.001 % of the study group for both), all confirmed with surgery and histology. Seventeen (65.38 %) myxomas were located in the left atrium (LA) (Fig. 1A-J), 7 (26.92 %) in the RA (Fig. 1K, L), 2 (7.69 %) with atypical localizations, one at the mitral anterior leaflet chorda, the other originating from the pulmonary valve, 19 (73.07 %) with pedicles originating from fossa ovalis, 6 (23.07 %) sessile masses from atrial walls (Figure 1).

Five fibroelastomas (11.54 % of benign tumors; 3.94 % of cardiac masses, 0.007 % of the study group) were identified incidentally. Three of them small, sessile, immobile masses, two located on the atrial side of the mitral anterior leaflet, one on the atrial side of the posterior leaflet. The other two fibroelastomas were small, mobile masses with short pedicles, one on the pulmonary valve and the other attached to the tricuspid anterior leaflet chorda (Fig. 1M-P).

One lipoma and one fibroma were also incidentally observed. Lipoma was located at the left ventricular (LV) posterior wall, originating from epicardium, it was the only benign cardiac tumor definitely diagnosed by CMR. Fibroma was located on the ventricular basis of posterior mitral leaflet with undetermined preliminary diagnosis (3.03 % of benign tumors, 0.79 % of cardiac masses, 0.001 % of the study group for both) (Supplementary Table 1, Figure 1).

Primary malignant cardiac tumors

Three primary malignant tumors of the heart were identified (0.004 % of the study group). One rhabdomyosarcoma (33.33 % of malignant tumors, 0.79 % of cardiac masses, 0.001% of the study group) and 2 angiosarcomas (66,67 % of malignant tumors, 1.574 % of cardiac masses, 0.003 % of the study group) (Supplementary Table 2, Figure 2). The rhabdomyosarcoma was a poly-lobulated, mobile mass originating from the posterior wall of the LV myocardium, completely filling the LV cavity and prolapsing into the LV outflow tract towards the aortic lumen, also infiltrating the right ventricle (RV) (Fig. 2A-D), with desmin-positive histology (Fig. 2E, F). Both angiosarcomas were huge masses originating from right atrioventricular groove infiltrating RA wall and cavity and RV lateral wall and pericardium (Fig. 2G-I), confirmed by histology (Fig. 2J), accompanied by pericardial effusion.

Secondary malignant cardiac tumors

These patients were histologically proven primary noncardiac cancers referred for echocardiographic examination of cardiac functions before initiation of chemotherapy while they were on follow up in other clinics. In most of the patients, echocardiographic examinations were suboptimal due to deteriorated general condition. Because of limited body motion and difficulty to achieve standard echocardiographic imaging planes, CMR and / or CT were predominantly used for diagnosis.

Cardiac metastases or invasions of cancers were detected in 20 patients (15.75 % of cardiac masses, 0.03 % of the study group), with male dominancy (55 %). One of the cases were published before ¹⁸. Malignancies with cardiac metastases consisted of lymphoma (n=6, 30 %), mainly B-cell lymphomas (n=5) (Fig. 3 A, B); lung cancer (n=5, 25 %) (Fig. 3, C); sarcomas of bone and soft tissue (n=3, 15 %); breast cancer (n=2, 10 %); renal cell carcinoma (n=1, 5 %) (Fig. 3, D); hepatocellular carcinoma (n=1, 5 %) (Fig. 3 E); stage IV thymoma (n=1, 5 %); papillary thyroid cancer (n=1, 5 %) (Fig 3, F). Secondary cardiac tumors were predominantly observed in the atria (n=12), majority in the RA (n=9). Surgery was performed for only 7 patients with large RA masses causing symptoms of obstruction, and histology proved invasions or metastases of the primary tumor to the atrium (Supplementary Table 3, Figure 3).

Cysts

Intracardiac cysts were found in 3 patients (2.36 % of cardiac masses, 0.004 % of the study group), all were hydatid cysts. The localizations of the cysts were bi-ventricular apical region (Fig. 4A-C), interventricular septum (Fig. 4D-F), LV lateral wall (Fig. 4G, H), all were confirmed by CT and / or CMR, with positive indirect hemagglutination tests. All patients underwent surgery (Fig. 4, F), and histology proved the diagnosis (Fig. 4, I) (Supplementary Table 4, Figure 4). Two of three cases were published before ^{19, 20}.

Thrombi

An intracardiac thrombus was identified in 68 patients (53.54 % of cardiac masses, 0.104 % of the study group). Thirty one patients (45.59 %) had underlying cardiac diseases, 37 patients (54.41 %) with non-cardiac disorders. Ischemic heart disease with low ejection fraction (EF %), with dilated left ventricle and prominent regional wall motion abnormalities (n=12, 38.71%, EF 20-40 %) was the first range of cardiac disease related intracardiac thrombi, followed by coexistence of hypertension and atrial fibrillation (n=8, 25.8 %), valvular heart disease (n=6, 19.35 %), and a few patients with hypertrophic obstructive cardiomyopathy, peri-myocarditis, biventricular non-compaction, ruptured sinus of Valsalva, generalized atherosclerosis (n=1, 3.22 % for each). The majority of intracardiac thrombi with non-cardiac disorders was associated with malignancies (n=17, 45.94 %) followed by autoimmune diseases (n=13, 35.13 %); chronic kidney disease (n=4, 10.81 %), deep venous thrombosis related with immobilization (n=2, 5.40 %), and hereditary spherocytosis (n=1, 2.70 %) (Figure 5, Supplementary Table 5).

The thrombi developed in patients with cardiac diseases were mainly located in the left heart chambers; those with systolic dysfunction in the LV (n=16), hypertension and valvular heart disease accompanied by atrial fibrillation in the LA (n=8). All of the patients received anticoagulant treatment, five patients were operated on.

Intracardiac thrombi of the patients associated with malignancies (n= 17) were predominantly located in the RA (n=11), RV was the secondary heart chamber (n=3). Malignancies accompanied by thrombi were; lung cancer (n=4) (Fig. 5 A,B), renal cell carcinoma (n=3) (Fig. 5C), lymphoma (n=3), and single cases of endometrial (Fig. 5D), esophageal (Fig. 5E,F), breast, ovarian (Fig. 5G,H), gastric cancers, leiomyosarcoma and chronic lymphocytic leukemia. All of the patients received anticoagulant treatment, only a patient with breast cancer with a very large thrombus in the RA was operated. The autoimmune diseases (n=13) predominantly consisted of Behçet's disease (n=7) (Fig. 5I, J) followed by rheumatoid arthritis (n=2) (Fig. 5K), lupus erythematosus with antiphospholipid syndrome (n=2) (Fig. 5L), Takayasu arteritis (n=1) and Wegener granulomatosis (n=1). The most frequently involved cardiac chamber in autoimmune diseases was RA (n=9), and infrequently LA (n=2), LV (n=1) and ascending aorta (n=1). Wegener granulomatosis, which was published before ²¹ with a large thrombus in the left ventricle underwent surgery, and others received medical treatment. Four chronic kidney disease patients on hemodialysis had 2 RA (Fig. 5M-O), 1 LA and 1 RV large thrombi, three of whom were operated. Two patients with deep vein thrombosis, due to trauma and tibia fracture in one and diabetic foot ulcer in the other had RV thrombi followed by pulmonary embolism, were treated medically, details can be viewed from Supplementary Table 5.

Discussion

This retrospective, cross-sectional study demonstrated 127 (0.195 %) cardiac masses, consisted of 33 (0.050 %) primary benign, 3 (0.004 %) primary malignant, 20 (0.030 %) secondary tumors, 3 (0.004 %) cysts and 68 (0.104 %) thrombi respectively.

Primary tumors of the heart are rare, based upon the data of autopsy series, the frequency of primary cardiac tumors ranges from 0.001 % to 0.03 %, 10 % malignant, 90 % benign ^{1,3,12,15}. The majority of

benign tumors are myxomas followed by papillary fibroelastomas, and very rare fibroma and lipoma¹⁵. In a report of 323 operated consecutive patients of primary cardiac tumors, 94 % were benign and 50 % were myxomas¹². Primary malignant cardiac tumors are predominantly sarcomas; angiosarcoma and undifferentiated sarcomas are the most prevalent⁴. Although our series consisted of patients referred to the echocardiography laboratory in a university hospital, the frequencies of the primary benign and malignant tumors is in consistent with autopsy and surgery based data and literature.

Specific cardiac tumors have a predilection for certain locations, 75-85 % of myxomas arise in the LA, 15-20 % from the right atrial septum, usually solitary, with a pedicle attached to the atrial septum at the border of the fossa ovalis membrane, and the remainder from a variety of sites^{10, 12, 14}. A retrospective analysis of 194 myxomas operated within fifty years have experienced that, the LA was the most common location and atria were significantly more involved than the ventricles⁶. In our series, in accordance with these previous statements, majority of the myxomas were located in the LA, less in the RA, most of them originating from fossa ovalis with a pedicle, and few sessile masses. Myxomas with atypical locations are rare in the literature²².

Papillary fibroelastomas are small benign endocardial papillomas, the second most common primary benign cardiac tumors that invariably develop on aortic and mitral valves, left ventricular endocardium and tricuspid valves, but may arise anywhere in the heart^{12, 14}. An analysis of 725 histopathologically confirmed papillary fibroelastomas have demonstrated that, 77 % of them originate on the valves, 23 % in the endocardial nonvalvular surface². In the present study, fibroelastomas were located at the mitral leaflets and tricuspid valve chorda, incidentally no fibroelastomas in the aortic valve. The lipoma and fibroma of the heart are rare tumors, lipoma with a predilection for the epicardium or endocardium, fibroma invariably located in the ventricles^{12, 14}. In our series, the single lipoma was imaged at the LV posterior wall originating from the epicardium and fibroma at the ventricular basis of posterior mitral leaflet, a rather atypical location.

Angiosarcomas account for approximately 37 - 40 % of cardiac sarcomas and typically present in the right atrioventricular groove, with frequent involvement of the pericardium and RA wall, with short survival²³. Rhabdomyosarcomas derived from striated muscle are distinctly rare, accounting for 0 % to 5 % of primary cardiac sarcomas and most cases appear in children with poor survival²³. The two angiosarcoma and one rhabdomyosarcoma in our series were in full agreement with the literature in terms of frequency, localization, tumor characteristics and surveillance.

Although primary cardiac tumors are rare, the frequency of secondary metastatic tumors to the heart in autopsy studies is between 0.7 % - 3.5 %, up to 9.1 % in patients with known malignancies^{13, 24, 25}. Tumors can reach the heart via 4 pathways: hematogenous or lymphatic spread, transvenous or direct extension¹³. Spread by the hematogenous route generally gives rise to myocardial or endocardial metastases and is common with melanoma, lymphoma, and sarcoma, whereas spread by the lymphatic route will often result in pericardial and epicardial tumor involvement, as with many epithelial tumors

such as lung and breast¹³. Certain tumors can extend into the inferior vena cava and grow into the RA via transvenous extension¹³. In the present study, cardiac metastases were diagnosed in 20 patients, when evaluated in terms of frequency; lymphoma, lung cancer and sarcoma were the majority of the secondary metastatic tumors, followed by breast cancer. Lymphoma metastases were remarkably in the LV suggesting hematogenous spread, whereas lung cancer metastases predominantly in RA suggesting transvenous extension, in fact, secondary cardiac tumors were mostly observed in the atria, most of them in the RA which supports the transvenous extension.

Cardiac echinococcosis is an uncommon disease, with an estimated prevalence ranging from 0.5 % to 2 %²⁶. In published series, involvement of all sites of cardiac structures have been reported^{19, 27, 28, 29}. Three intracardiac cysts in this study were hydatid cysts with myocardial involvement, which revealed the fact of our endemic character, incidentally no other cysts were encountered.

Thrombi are the most common intracardiac masses, located within the atria, and/or both ventricle cavities with an underlying cardiac disease or hypercoagulable state. Left ventricular thrombi usually occur in the setting of systolic dysfunction, with or without aneurysm formation in ischemic heart disease and dilated cardiomyopathy¹⁵. Thrombi in the absence of underlying cardiac disease are much less common¹⁵. Conditions such as acute coronary syndrome within 6 months, newly diagnosed atrial fibrillation, patients with prosthetic valves where thrombus formation is expected and device and catheter induced thrombi were excluded in our series. De-novo intracardiac thrombus was identified in 68 patients and the majority of intracardiac thrombi were associated with malignancies, followed by autoimmune diseases, ischemic heart disease with systolic dysfunction and low ejection fraction, hypertension associated with atrial fibrillation and valvular heart disease. It should be noted here that, the most frequent cause of cardiac thrombus in patients with autoimmune diseases was Behcet's disease which has a peculiar geographical distribution in our country. The majority of thrombi were in the RA and LV and the less in the LA. The RA thrombi predominantly were associated with malignancy and autoimmune diseases, whereas LV thrombi were detected in patients with LV systolic dysfunction and, LA with valvular heart disease, hypertension and atrial fibrillation. The RV thrombi were seen in patients with deep vein thrombosis and malignancies. In the literature, other than case reports, there is no clinical series regarding the localization and etiology of intracardiac thrombi. An autopsy study reporting the largest series of intracardiac thrombi of 11,724 autopsies performed in 15 years has found 276 patients (2.4 %) with intracardiac thrombi, of these, 45 patients had intracardiac thrombi that were unrelated to primary cardiac disease, the most recognizable risk factor was underlying cancers (24.4 %) which supports our results³⁰.

Conclusion

Although cardiac masses are rare entities, they are being increasingly recognized in the current era by means of advanced imaging modalities. In the current analysis, we classified and presented various categories of cardiac masses systematically in relation to concomitant disease, symptoms and their locations in the heart chambers. The majority of benign tumors were myxoma, the most common

secondary malignant tumors that metastasized to the heart were lymphoma and lung cancers, and the thrombi associated with malignancies and autoimmune diseases were the most frequent. This descriptive analysis may, therefore, contribute to appropriate diagnosis of patients with cardiac mass, which principally rely on correct recognition of the masses made generally based on their localizations and imaging characteristics.

Declarations

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None declared.

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DISCLOSURES

None declared.

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Tables

Table 1. Frequency of cardiac masses, and the percentages of primary and secondary tumors, cysts and thrombi in the study group

N : 64,862 patients			
Cardiac Mass	No of Patients	Cardiac Mass %	Study Group %
Primary Tumor	36	28.35	0.056
*Primary Benign Tumor	33	25.98	0.050
*Primary Malignant Tumor	3	2.36	0.004
Secondary Malignant Tumor	20	15.75	0.030
Cyst	3	2.36	0.004
Thrombus	68	53.54	0.104
TOTAL CARDIAC MASS	127		0.195

Figures

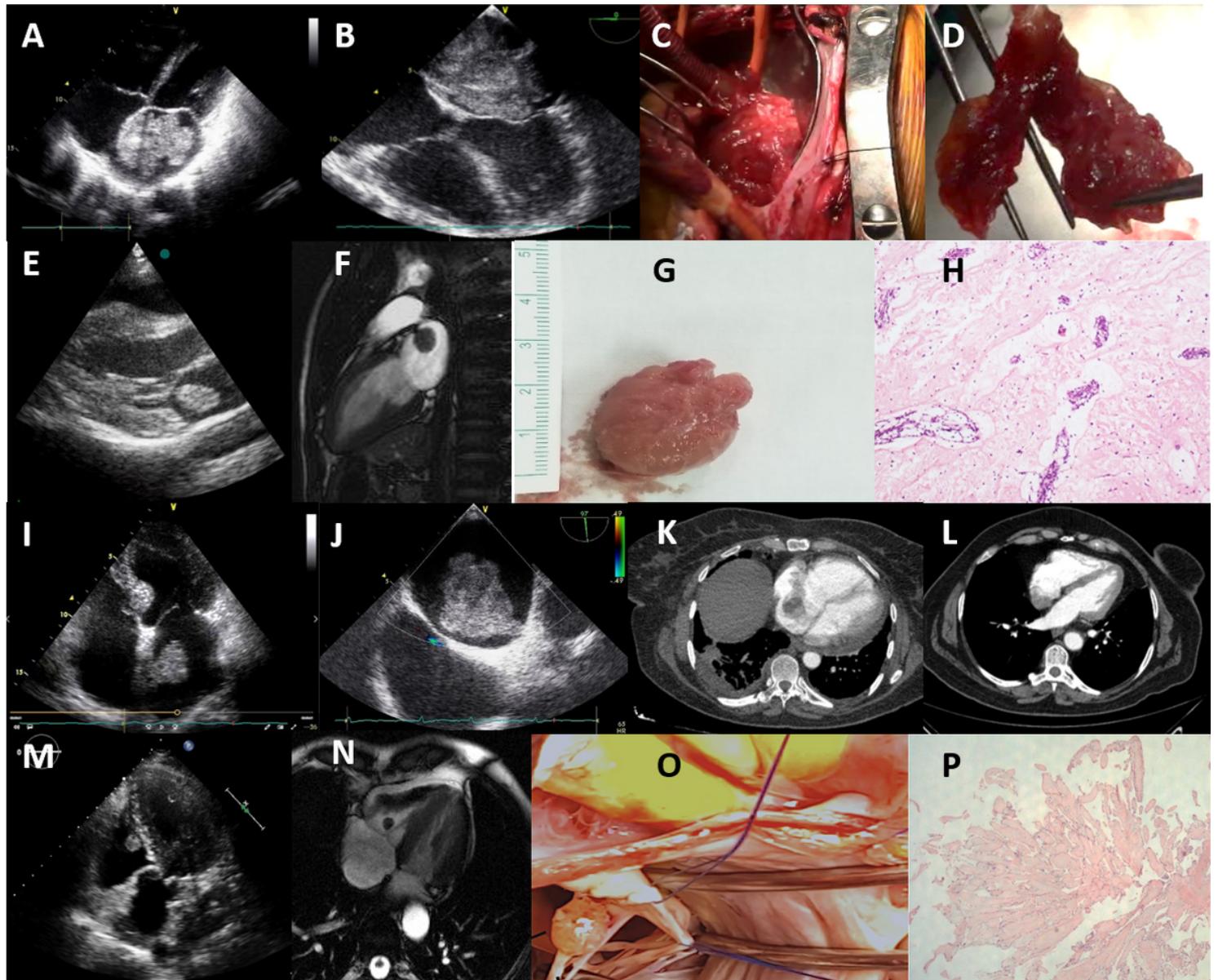


Figure 1

Primary benign tumors of the heart. (A) giant left atrial myxoma, 2D TTE apical four chamber view, (B) 2D TEE mid-esophageal four chamber view, polylobulated mass of the tumor in the left atrium, attached with a pedicle to the fossa ovalis, prolapsing through the left ventricular cavity during diastole, (C) urgent surgical resection of the myxoma via open sternotomy, intraoperative view, a lobulated and pedunculated huge mobile mass (D) gross examination of the tumor, a fragile, polylobulated mass, histology in consistest with myxoma. (E) left atrial mobile, ball shaped myxoma, 2D TTE, parasternal long axis view, a well circumscribed mass in the left atrium, (F) CMR two-chamber SSFP cine, a hypointense mass with a short pedicle originating from the superior wall of the left atrium, (G) gross view of the surgically resected mass, smooth surface, bright pink colour (E) histology shows intense perivascular benign neoplastic cells and rare same type cells in myxoid stroma, compatible with myxoma, hematoxylin-eosin X 100. (I) 2D TTE apical four chamber view of a pediculated left atrial myxoma originating from the interatrial septum, suggesting a thrombus with heterogeneous appearance; (J) 2D TEE modified bicaval position,

pediculated left atrial myxoma adjacent to the superior vena cava and patent foramen ovale; (K) CT, right atrial lobulated myxoma originating from fossa ovalis, extending through the atrial cavity; (L) CT, right atrial myxoma originating from the posterior right atrial wall. (M) papillary fibroelastoma in the right ventricle, 2D TTE apical five chamber view, a well-defined, nodular, mobile mass, 1 cm in diameter originating from the anterior tricuspid leaflet chorda; (N) CMR SSFP cine four-chamber view, (O) gross examination of the surgically resected benign tumor, a translucent and gelatinous mass; (P) histology shows a benign tumor with multipl papillary fronds of different size that consisted of an acellular matrix and surrounded by single layer of endothelial cells, hematoxylin-eosin X 100. 2D TTE: two-dimensional transthoracic echocardiography; 2D TEE: two-dimensional transesophageal echocardiography; CMR: cardiac magnetic resonance imaging; CT: computed tomography ; SSFP: steady state free processing.

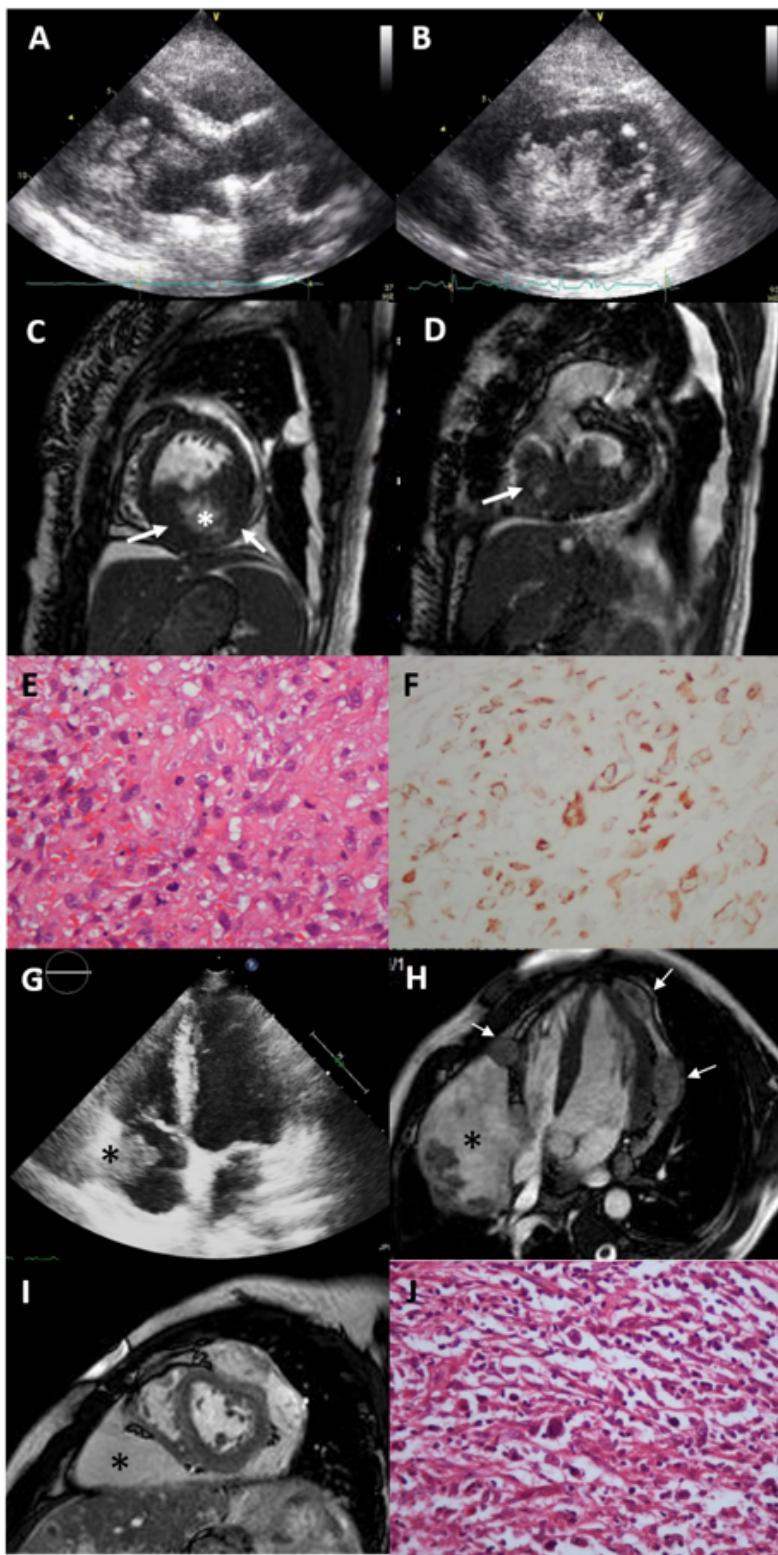


Figure 2

Primary malignant tumors of the heart. Left ventricular endocavitary rhabdomyosarcoma, (A) 2D TTE, parasternal long-axis view, polylobulated mass of the tumor in the left ventricle; (B) parasternal short-axis view of the tumor in the left ventricular cavity; (C) CMR, endocavitary tumor originating from the inferior wall of the left ventricle (arrow) with cystic and necrotic areas at the centrum (*); (D) tumor also infiltrates the right ventricle (arrow); (E) histology : pleomorphic malign tumor cells of rhabdomyosarcoma, mitotic

figures and atypical cells, hematoxylin-eosin X 200; (F) positive desmin immunochemistry in tumoral cells X 200. High grade angiosarcoma; (G) 2D TTE apical four chamber view, tumor mass (*) in the right atrial cavity, infiltrating right atrial wall, (H) contrast-enhanced SSFP cine CMR, nodular lesions of the tumor (arrows) infiltrating left and right ventricular myocardium and epicardium, with a large mass of tumor in the atrioventricular groove and right ventricular myocardium (*) narrowing the right heart chambers; (I) CMR, short axis SSFP, large tumor mass (*); (J) High grade angiosarcoma, irregular malignant spindle cells haphazardly arranged , hematoxylin-eosin x 40. 2D TTE: two-dimensional transthoracic echocardiography; CMR: cardiac magnetic resonance imaging, SSFP: steady state free processing

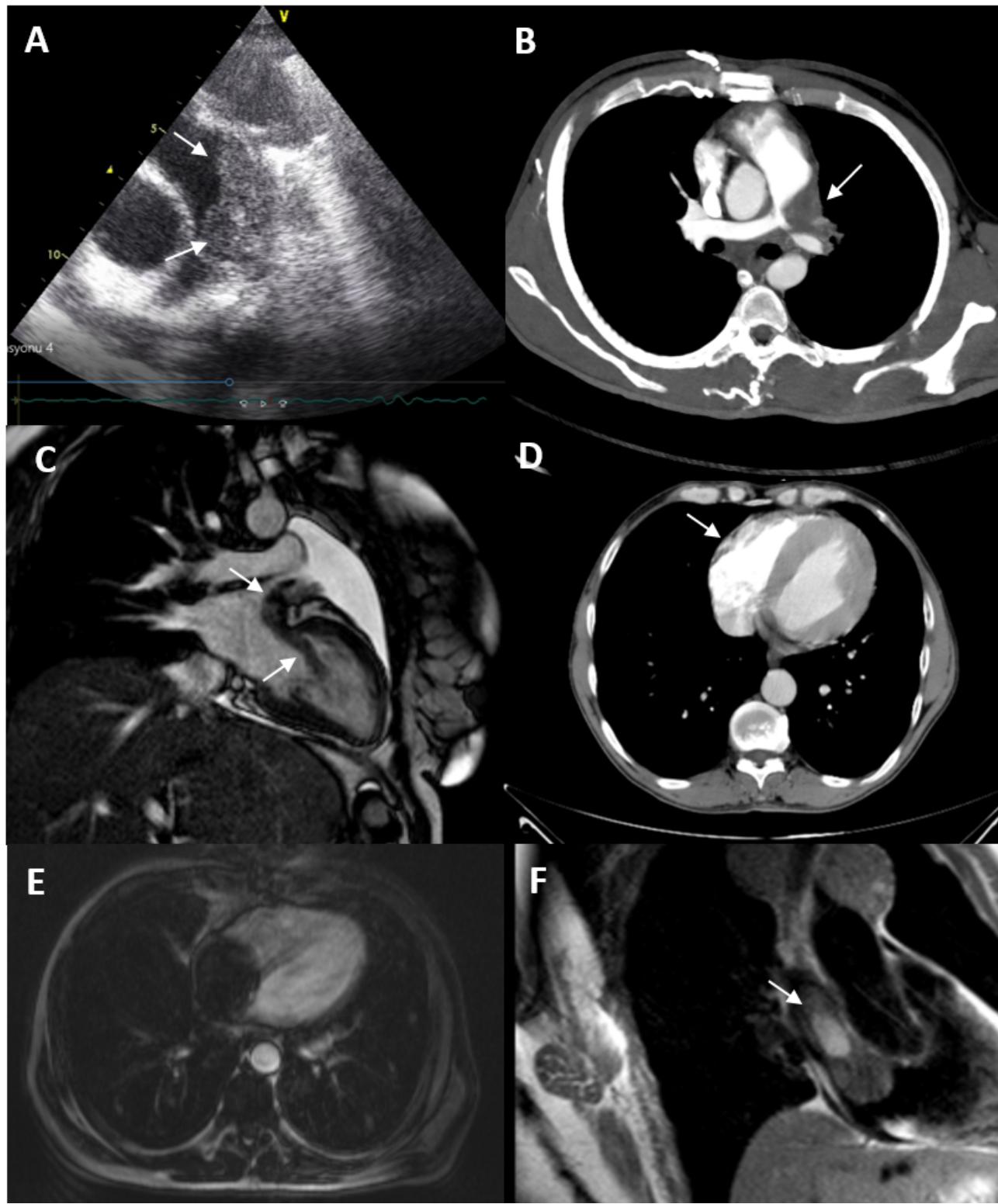


Figure 3

Secondary malignant tumors of the heart. (A) B-cell lymphoma 2D TTE, short axis view; (B) contrast CT, lymphoma infiltrating the main pulmonary artery; (C) Malignant mesenchymal intrabronchial tumor CMR, cardiac invasion of the tumor via left pulmonary vein (18); (D) Renal cell carcinoma CT, right ventricular wall invasion by the tumor; (E) Hepatocellular carcinoma CMR, right atrial mass, almost filling the whole atrial cavity; (F) Papillary thyroid cancer CMR, right atrial invasion of the carcinoma. 2D TTE: two-

dimensional transthoracic echocardiography; CMR: cardiac magnetic resonance imaging; CT: computed tomography

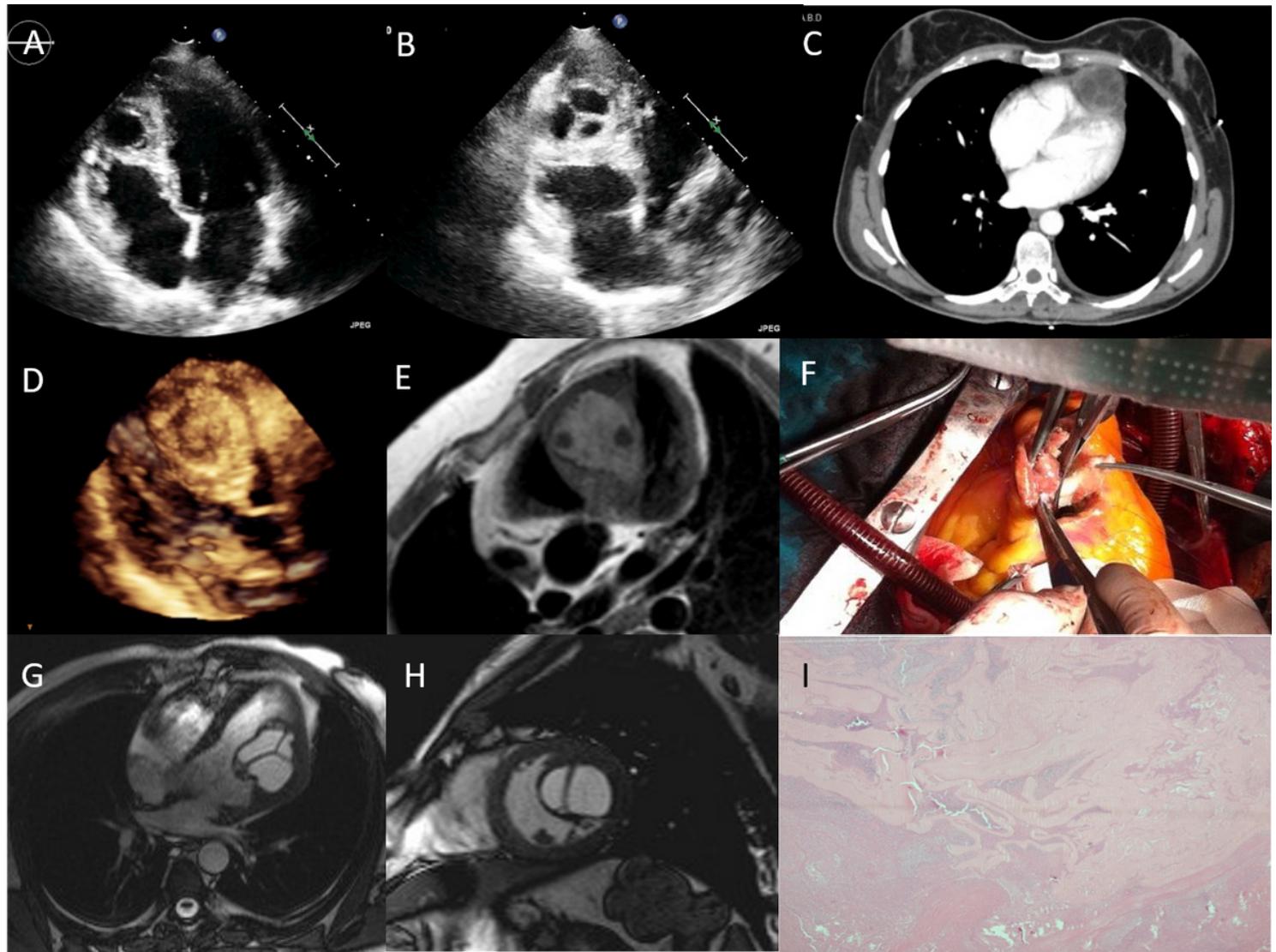


Figure 4

Cardiac hydatid cysts with various myocardial locations. (A) 2D TTE apical four and (B) five chamber views, a multiseptated anechoic lesion located at the apical regions of both ventricles; (C) a contrast-enhanced thoracic CT scan reveals a septated cystic mass lesion located in the apex of both ventricles; (D) 3D TTE apical long axis view, a granulated spheric mass located within the interventricular septum, with patchy hypoechoic regions (19); (E) CMR reveals hydatid cyst located within the interventricular septum with water content and a few daughter cysts (19); (F) gross examination of the surgically resected hydatid cyst (19); (G) SSFP cine four-chamber (20) (H) short-axis images of CMR showing left ventricular hydatid cyst with septations growing from the lateral wall into the cavity (20) (I) histological examination of the echinococcal lesion with cuticular membranes in cystic content, hematoxylin-eosin X 40. 2D TTE: two-dimensional transthoracic echocardiography; CT: computed tomography; 3D TTE: three-dimensional transthoracic echocardiography; CMR: cardiac magnetic resonance imaging; SSFP: steady state free processing

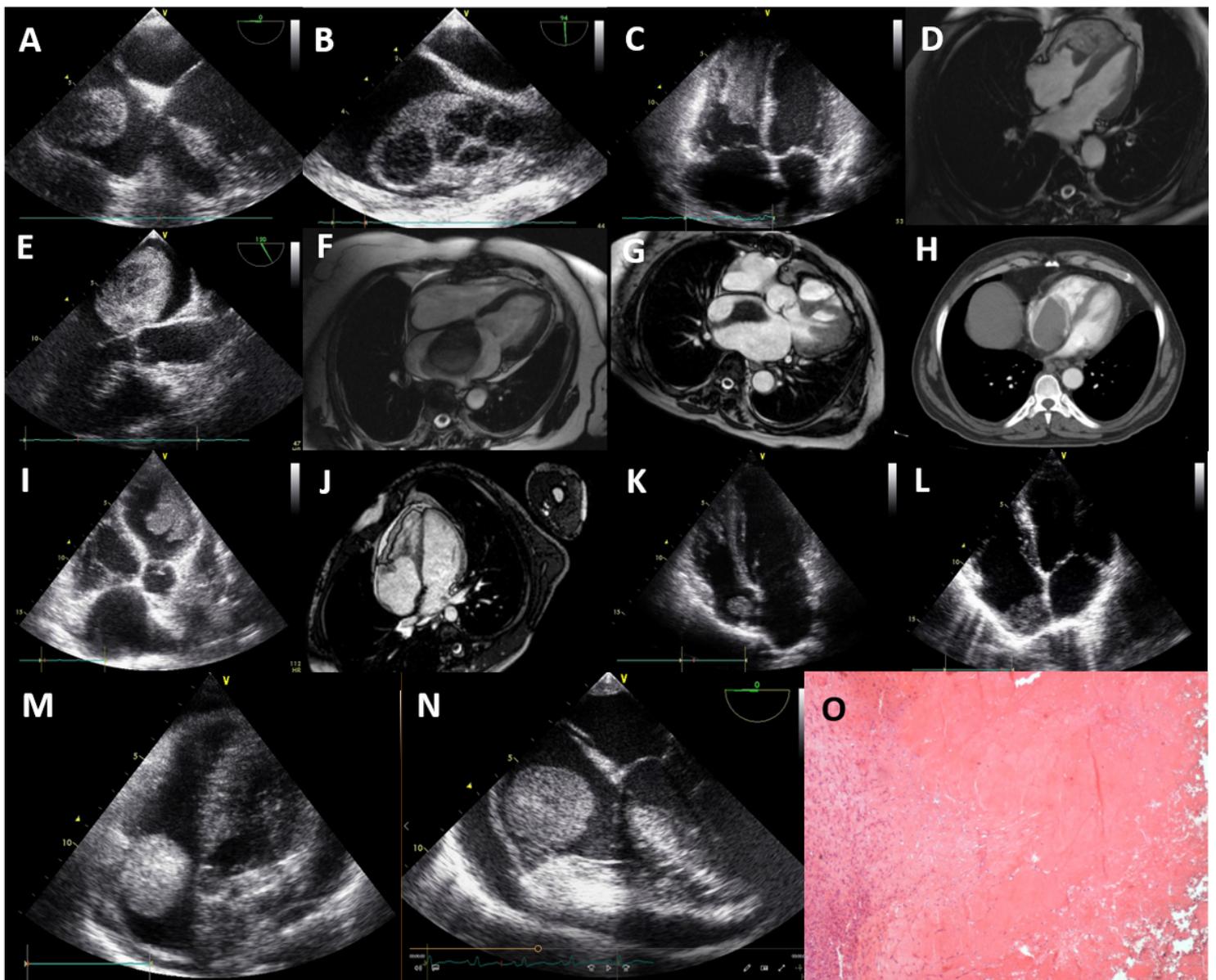


Figure 5

Intracardiac thrombi with noncardiac disorders. (A) Non small cell lung cancer, 2D TEE midesophageal four chamber view, a large thrombus in the right atrium with lytic areas and (B) 2D TEE bicaval zoomed view, the thrombus extending from vena cava superior through the right atrial cavity; (C) Renal cell carcinoma, CT, thrombus almost completely filling the left atrium; (D) Endometrial cancer, CMR, a thrombus extending from vena cava inferior through the right atrium; (E) Esophageal cancer, 2D TTE apical four chamber view and (F) CMR four chamber view, a thrombus filling the right ventricular cavity and extending through the mid ventricular level; (G) Ovarian cancer, 2D TEE midesophageal long axis view and (H) CMR four chamber view, thrombus with hypoechoic regions, filling left atrium; (I) Behcet's disease, 2D TTE apical five chamber view, a massive, lobulated, mobile left ventricular thrombus; (J) Behcet's disease, CMR, four chamber view, an immobile thrombus infiltrating the right atrial side of the tricuspid valve and endocardial fibroelastosis at the right ventricular wall; (K) Rheumatoid arthritis, 2D TTE apical four chamber view, right atrial immobile thrombus; (L) Systemic lupus erythematosus with (O) histology.

antiphospholipid syndrome, 2D TTE, apical four chamber view, right atrial immobile thrombus; (M) Chronic kidney disease, 2D TTE apical four chamber view, right atrial giant, ball shaped thrombus in a young patient and (N) 2D TEE midesophageal four chamber view, a large granulated mass with hyper and hypodense regions filling right atrium and obstructing the tricuspid valve at diastole, and moderate pericardial effusion, (O) after urgent surgical removal, histology confirmed a thrombus with organized fibrin mass, hematoxylin-eosin X 200. 2D TTE: two-dimensional transthoracic echocardiography; 2D TEE: two-dimensional transesophageal echocardiography; CMR: cardiac magnetic resonance imaging

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